

PATENT SPECIFICATION

DRAWINGS ATTACHED

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International Classification:—G 02 b 7/00.

COMPLETE SPECIFICATION

Mountings for Heavy Instruments

I, WINFIELD HAROLD PETERSON, a citizen of the United States of America, residing at F140 Wyview, Provo, Utah, United States of America, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to mountings for instruments, particularly to mountings for optical and radio astronomical telescopes, radar antennas, solar concentrators and like instruments.

Mountings for supporting and orienting (aiming, pointing) large optical and radio astronomical telescopes, solar concentrators, radar antennas, and like instruments, now in use (hereinafter collectively called instruments) commonly support and orient the instrument on structures that are mounted on two axles which represent the axes of rotation. As the instruments have increased in size, due to the desire of scientists to probe farther and farther into space, mountings for the instruments have become more and more difficult to design and build. This is due mainly to the enormous weight which the mountings must support in such a manner as to allow precise and delicate adjustments in aiming and moving the massive instruments in their tracking of terrestrial and celestial objects. It is apparent that with the prior art means of mounting and moving or aiming these great instruments, the size of the instrument has been in some measure restricted by the enormity of the mounting necessary to support it. For example, it appears that the mirror of the optical reflecting telescope has been practically limited to the 200 inch size (now on Mount Palomar in Southern California) because of the difficulties involved in designing and building mountings for a much

larger mirror.

The enormous weight of these instruments resting upon their support axles creates such stresses that accurate and precise alignment during the entire period of study of object becomes increasingly difficult to maintain due to deformations and deflections in the mounting as the instruments increase in size. The tremendous mass of these large instruments and their mountings must be so finely balanced as to allow delicate, predetermined movement without developing excessive vibration or misalignment in their element trains (as hereinafter defined).

Recent theoretical developments in the field of astronomy have introduced the need for instruments so large that some of them are not now movable at all except with the rotation of the earth. An example of this is the 1000-foot diameter, fixed position, spherical, radio telescope antenna at the Arecibo Ionospheric Observatory in Puerto Rico. It is evident that if these gigantic instruments could be moved for tracking celestial objects, as the present smaller astronomical telescopes are by virtue of their equatorial or altazimuth mountings, the utility of these very large instruments would be tremendously increased.

To overcome the difficulties and limitations of prior art mountings for instruments, it is an object of this invention to provide a mounting in which none of the weight of the element train is borne by the orienting mechanism.

It is another object of this invention to provide mountings for various types of instrument on which strong winds have very little disturbing effect.

It is another object of this invention to provide mountings for optical and radio astronomical telescopes, solar concentrators, radar antennas and the like which reduced

decollimation of their element trains (as hereinafter defined) to a minimum.

It is a further object of this invention to provide mountings for astronomical, 5 solar, and radar or other instruments far larger than those now in existence or which otherwise appear practicable.

Several terms are now defined which are used herein to describe the features asso- 10 ciated with applications of the invention.

The term "telescope" is used to indicate both optical and radio telescopes, unless the adjectives "optical" or "radio" are used to differentiate the two.

The term "element train" is used to indicate the optical element or train of opti- 15 cal elements in an optical telescope (reflecting spherical or parabolic mirrors, objective lenses, eyepieces, flats, hyperboloids, etc.), or the receiving element or train of receiving elements in a radio telescope (parabolic antenna, feed, etc.), or the concentrating element or train of concentrating elements in a solar concentrator (spherical or para- 20 bolic reflector, target, etc.).

The term "tube" or "tubular structure" as applied to telescopes will be used to include only those structural elements which directly support and collimate the element 30 train. In optical telescopes, the term "tube" refers to the structural components directly supporting the optical elements only and not to the mounting, which supports and orients or aims the tube of the instru- 35 ment.

The term "orienting means" is used to indicate the axis or axes, commonly two mutually perpendicular axes, and their related structures, which orient or aim the in- 40 strument. The orienting means is mainly of three types; equatorial, altazimuth, and universal.

The term "supporting means" is used to indicate the means used to support the mass 45 and weight of the instrument, e.g. in the case of a telescope the tube and element train.

The term "mounting" is used to include the supporting means, and the orienting 50 means.

According to the invention an instrument mounting comprises a base, a bearing member having substantially universally rotatable load-bearing support on said base, co- 55 operating orienting means on said member and base distinct from said load-bearing support for independently displacing said member about at least two axes, said orienting means being substantially free from forces induced by the weight of said bearing member and of an instrument carried thereby in use, and comprising an orientation member external of said bearing member and rotatively mounted on said base 60 for rotation in a plane about a first axis,

means connecting said bearing member to said orientation member to rotate said bearing member with said orientation member about said first axis, said connecting means also permitting rotation of said bearing 70 means relative to said orientation member and said base about a second axis.

Five preferred embodiments of the invention are now more particularly described with reference to the accompanying draw- 75 ings wherein:—

Figure 1 is a perspective view of a mounting according to a first embodiment of the invention, showing an orientation ring and a sphere; 80

Figure 2 is a perspective view of a modification of the mounting shown in Figure 1 in which gear arrangements for rotating the sphere about two axes are shown;

Figure 3 is a sectional view of a further 85 modification of the mounting shown in Figure 1, showing another means for driving the sphere about a polar axis;

Figure 4 is a sectional view of a mounting according to a second embodiment of the invention depicting a sphere supported on a film of pressurized gas; 90

Figure 5 is a perspective view of a third embodiment of the invention showing a sphere supported by ball casters; 95

Figure 6 is a perspective view of a fourth embodiment showing the alignment of a polar axis hole in a socket-base with a polar axis slot in a sphere;

Figure 7 is a perspective view of a mount- 100 ing including a fifth embodiment of the invention in which a sphere is universally mounted so that rotation may be produced about three axes and in which the plane of an orientation ring may be variously 105 inclined and rotated with respect to a fixed base;

Figure 8 is a perspective view of the embodiment shown in Figure 1 which shows a reflecting telescope mounted within the sphere; and 110

Figure 9 is a perspective view of the embodiment shown in Figure 2 containing a reflecting structure focused on a target. (The reflecting structure is representative of a radar antenna, a radio telescope antenna, a solar concentrator, and the like). 115

In its simplest form, a mounting according to the invention consists of five elements. Each of the five elements are modifiable in 120 form but the functions they perform remain substantially the same.

The five elements of the mounting depicted in Figure 1 are a bearing member 1, orientation ring 2, axles 3, bearing member support 4, and ring-plane orientation mechanism 5. Support 4 may take many varied forms, as may ring-plane orientation mechanism 5. (The phrase "ring-plane" means the geometric plane on which orienta- 130

tion ring 2 lies.) Thus the features of the mounting include a bearing member 1 having a spherical outer surface resting in a fixed socket base 10 having a slotted spherical socket, such as is shown in Figure 1, or other support means as will be described later. (In this application the word "sphere" or "spherical" is also used to describe less than a complete sphere, and the word "ring" is used to describe a segmental part of a ring as the drawings indicate.) Sphere 1 is rotatably attached to ring 2 by axles 3,3. Socket-base 10 is slotted to receive orientation ring 2 so as to hold the plane of orientation ring 2 fixed with respect to socket-base 10 while at the same time allowing orientation ring 2 to slide in slot 5a and rotate about its geometric center. In other words, the ring-plate orientation mechanism orients the plane of the orientation ring while at the same time allowing the ring to rotate about its geometric center. (Hereinafter reference to orientation ring 2 will be simply as ring 2). Ring 2 and axles 3,3 bear none of the weight of sphere 1. Thus, the weight of sphere 1 is borne by socket-base 10. Socket-base 10 is only one form of the bearing member support; other forms will be described hereinafter. Figure 1 also shows the geometry of the axes involved in this form of the mounting. One axis of sphere rotation is formed by axles 3,3 which join sphere 1 and ring 2. This axis, 6, will hereinafter be referred to as declination axis 6. The second axis, 7, is formed by an imaginary line passing through the common center of ring 2 and sphere 1 and is always perpendicular to the plane of ring 2. Axis 7 will hereinafter be referred to as polar axis 7. Thus a rotation of ring 2 in slot 5a rotates sphere 1 about polar axis 7. The load bearing support of bearing member 1 on socket base 10 permits universal rotation of the former, i.e. rotation about any axis or axes e.g. the declination and polar axes referred to above.

Figure 2 illustrates mechanical means for rotating sphere 1 about its two axes 6 and 7, consisting of two worm gears. Part of ring 2 (Figure 2) as made into a worm wheel, 8, and is driven by means of worm 9 conveniently located in socket-base 10. This mechanism turns sphere 1 about polar axis 7. A similar arrangement employs worm-wheel 11 formed in a recess in the surface of sphere 1, and worm 12, suitably anchored in ring 2, is employed to turn sphere 1 on declination axis 6. Other gear arrangements may also be utilized to rotate sphere 1.

Figure 3 shows a non-gear means for rotating sphere 1 about its polar axis. Cable 12 is fastened at two end points on ring 2. Groove 13 encircles the outer circumference

of ring 2. Cable 12 rests in groove 13. A driving motor, or other mechanical power source 14, rotates pulley 15 which engages cable 12. When pulley 15 rotates, ring 2 is also rotated, and, in turn, sphere 1 is rotated on its polar axis.

Sphere 1 may also be supported above socket-base 10 by jets of gas, as shown in Figure 4, wherein pressurized gas in chamber 16 is conducted through jets 17 so that sphere 1 "floats" on a film of pressurized gas 18. This illustrates a modification of bearing member support 4.

Figure 5 is a perspective view of sphere 1 supported by ball casters 19. This illustrates still another modification of bearing member support 4 other than floatation on a fluid. Figure 5 also depicts another form of ring-plane orientation mechanism 5 in which ring 2 is a suitably curved rod or pipe. Sleeve 20 is anchored to base 21. Sleeve 20, preferably equipped with ball or roller bearings, holds the plane of ring 2 stationary but allows ring 2 to slip through sleeve 20 and thus rotate.

Whatever bearing member support is utilized, it should allow the sphere to rotate freely about at least two axes. Bearing member supports include three general groups according to the type of support employed: (1) Fluid-lubricating; (2) Mechanical; and (3) Combinations of Fluid-lubricating and Mechanical. Each of these general methods of sphere support allows rotation of the member upon its axes in such a manner that no axis bears any of the member's weight.

A common element in all the fluid lubricating type bearing member supports is the support or floatation of the members on lubricating or other fluid media. The fluid medium which supports the member may include water, mercury, lubricants, and any other suitable liquids and gasses.

Suitable mechanical bearing member supports include such devices as ball bearings, swiveled or ball casters and other similar means. It may also be desirable to combine both mechanical and fluid-lubricating types; in which, for example, most of the member's weight would be supported by floatation and the remainder by swiveled casters.

The mounting has thus far been described as being composed of five elements. The five elements are capable of considerable modification such as has been described for bearing member support 4 (Figure 1) and ring-plane orientation mechanism 5. The following describes a few modifications of the remaining three elements: bearing member 1 may be solid, hollow, partly skeletalized, or with perforations. The entire member will, in most cases, not be utilized, but usually only that part thereof which contacts bearing member support 4

and attaches to axles 3,3, unless a greater portion is required to provide the support for the instruments. Ring 2 in most cases will not be a complete circle. In almost
 5 all cases it will be only a segmental part of a ring but it must be at least half of a ring so as to attach to axles 3,3. Axles 3,3 may pass through the entire diameter of bearing member 1 and ring 2 or may merely be
 10 represented by two axles, one on each side of sphere 1.

The purpose of member 1 is to provide a foundation, containment vessel or "tube" for instruments or mechanisms which re-
 15 quire orientation about at least two mutually perpendicular axes for their successful operation.

The purpose of orientation ring 2 in Figure 1 is to establish the angular orientation of polar axis 7, with respect to socket-
 20 base 10, about which sphere 1 may rotate.

The purpose of declination axles 3,3 is to join a diameter of sphere 1 to a diameter of ring 2 so that sphere 1 may rotate within
 25 ring 2. The plane of this rotation is perpendicular to the plane of rotation about polar axis 7.

The purpose of bearing member support 4 is to support the weight of sphere 1 in such
 30 a manner that sphere 1 may rotate freely about its two axes 6 and 7, and in such a manner that the two axes of rotation bear none of the weight of the sphere with its contents.

The purpose of ring-plane orientation mechanism 5 is to establish the angular inclination, with respect to some fixed line in
 35 space, of the plane of ring 2.

Inherent in the mounting is another practical, but rather obscure feature. To simplify the description of this feature, reference will be made to Figure 6. A slot 22 penetrates
 40 hollow sphere 1. The center-line of polar axis slot 22 is formed by a plane intersecting sphere 1 in such a way that the plane passes through the center of sphere 1 and is perpendicular to declination axis 6. Polar axis slot 22 may extend around as
 45 much of sphere 1 as the application requires. Let the imaginary line representing polar axis 7 extend through socket-base 10. Let that line form the center line of a polar axis hole 23 in socket-base 10. When sphere
 50 1 is rotated on either or both axes 6 and 7, it will be observed that in all possible rotational positions of sphere 1, some part of polar axis slot 22 will always line up with polar axis hole 23, as long as the ends of slot 22 do not go past hole 23.

There is one other point where polar axis slot 22 will always line up with a fixed external hole, such as has just been described. This hole (not shown in Figure 6) is also
 60 centered on polar axis 7 but is on the opposite side of the sphere from polar axis hole

23.

It has been pointed out that the sphere may be used as a foundation or containment vessel or housing for one of a number of
 instruments. Very often such instruments
 70 require electrical power for their operation. The supply of such energy will almost certainly have to come from a source external to the sphere. It would therefore be necessary
 75 to bring the conduits or conductors of this energy in through a penetration in the sphere. If polar axis slot 22 is utilized as the sphere penetration and polar axis hole 24 as a fixed, immovable point of introduction for conduit 24, then regardless of how
 80 sphere 1 is rotated on its two axes 6 and 7, fixed conduit 24 will always find unhampered access into sphere 1 by passing up through polar axis hole 23 and polar axis slot 22, as long as the ends of slot 22 do
 85 not move past hole 23.

It should be noted that in some applications of the mounting the plane of ring 2 must always be held constant with respect to some fixed base, while in other applica-
 90 tions, it may be desirable to change the plane of ring 2 at will. For this latter application, different bearing member supports and ring-plane orientation mechanisms than previously described must of course be used.

Figure 7 demonstrates the use of sphere floatation as the bearing member support. The structure lying mostly below the surface of fluid 25 orients the plane of ring 2 in
 100 space while allowing ring 2 to rotate about its geometric center, but does not contribute to the support of sphere 1. In this "universal" form of the ring-plane orientation mechanism, the plane of ring 2 may be
 105 tilted or inclined, and rotated with respect to fixed base 26. Figure 7 also illustrates once again the great variation possible in both the support and the ring-plane orientation mechanism. The universal ring-plane
 110 orientation mechanism also demonstrates a method of orienting the rotations of sphere 1 about a third diameter or axis. Figure 7 shows this third axis as being coincident with vertical line 27 which passes through the center of, and is perpendicular to, fixed
 115 base 26.

Universal ring-plane orientation mechanism 28, underlying sphere 1 depicted in Figure 7, operates in such a way that the
 120 geometric center of sphere 1 never moves but is always in the same place with respect to fixed base 26. Universal ring-plane orientation mechanism 28 consists of fixed base 26, turntable 29 which rotates on fixed base 26 by means of wheels 30, and arch 31
 125 which serves as a track for ring-plane elevation guide 32. Arch 31 is of circular section and is concentric to sphere 1. Universal ring-plane orientation mechanism 28 allows the plane of ring 2 to be fixed in any angular
 130

position from vertical to horizontal by means of moving ring-plane elevation guide 32 along the gear track on arch 31. It also allows the plane of ring 2 to be revolved about vertical line 27, which passes perpendicularly through the center of fixed base 26, by rotating turntable 29. Thus it is possible to orient the rotations of sphere 1 about three separate diameters, or axes; one axis of rotation being coincident with vertical line 27 which passes through the center of, and perpendicular to, fixed base 26; the remaining two axes of rotation are mutually perpendicular to each other and are designated polar axis 7 and declination axis 6. All three axes intersect in the center of sphere 1.

Universal ring-plane orientation mechanism 28, which is only one form of the ring-plane orientation mechanism, enables the plane of ring 2 to be tilted or inclined at any angle or position whatsoever with respect to fixed base 26. Other forms of the ring-plane orientation mechanism described previously, held the plane of ring 2 fixed with respect to some fixed base 10 (Figure 2).

The application of sphere 1 as a movable platform, foundation, containment vessel, or "tube", for certain instruments or mechanisms that require rotation about two mutually perpendicular axes for their successful operation, illustrates the practicality and usefulness of the mounting according to the invention and its supremacy over other prior-art mechanisms. For example, an astronomical reflecting telescope, which is used to observe and to follow the apparent motion of celestial bodies through the heavens, is supported and oriented by means of two mutually perpendicular axes. One axis is positioned parallel to the earth's axis of rotation and is termed the "polar axis." The other axis, which is perpendicular to the polar axis, is termed the "declination axis" and afford the freedom of directing the telescope along the length of any celestial vertical circle. Rotation upon these two axes is necessary if the telescope is to be directed at any point in the hemispherical "dome" of the sky. If then a telescope, so mounted on two mutually perpendicular axes, is pointed at a heavenly body and one wishes to keep that body in view while the earth is rotating counterclockwise on its axis, the telescope need merely be turned clockwise on one axis, its polar axis, to keep that body in view. This type of telescope mounting is termed an "equatorial" mounting. Several types of equatorial mountings exist in prior art and are used extensively today.

The mounting of the invention can be used as an equatorial mounting for an astronomical telescope since it affords rotation about at least two mutually perpen-

dicular and intersecting axes. It is especially well suited to reflecting type telescopes though it could also be used to mount a refractor. In Figure 8, which shows a mounting for an astronomical telescope, the plane of ring 2 is fixed so that polar axis 7 is parallel to the earth's axis of rotation. This is done by orienting the plane of ring 2 parallel to the plane of the earth's equator.

Let us suppose that the diameter of a reflecting telescope mirror 32 mounted within the spherical bearing member 1 (Figure 8) is 400 inches. This size is two times the size of the world's largest reflecting telescope now in existence, (the 200-inch Mt. Palomar telescope). If the 400-inch mirror had a focal ratio of 3.3, the focal length of the mirror would then be 110 feet. At the focal point is located a structure called an observers cage 33, similar to the observers cage used in the present Mt. Palomar 200-inch telescope. The cage may support an observer, an eyepiece, and other auxiliary instruments. The requisite sphere diameter containing such a large 400-inch mirror would be about 120 feet. The entire 120 foot sphere depicted in Figure 8 could be easily enclosed in the present 137 foot diameter observatory dome of the Mt. Palomar observatory. Thus, by utilizing the mounting as a mounting for a large reflecting astronomical telescope, the diameter of the greater reflector may be increased two times (to 400 inches) and still be enclosed in a space smaller than the size now required to house a telescope having a 200-inch mirror supported by presently known equatorial mountings. In addition, if the structural complexity of prior-art equatorial mountings for very large reflecting telescopes is compared with this relatively simple mounting, it can readily be seen that a great savings in construction costs of such telescopes can be realized. This is especially apparent from the fact that reflecting telescope optics mounted within a spherical mounting need no additional observatory dome to house them. The mounting may serve both as a simple equatorial mounting for telescope optics and also as a complete observatory enclosure for the same. That the mounting may also serve as the observatory enclosure arises from the fact that a sphere is a reasonably aerodynamically streamlined structure against which strong winds have little disturbing effect.

An additional beneficial feature in the use of the invention as a mounting for astronomical telescopes arise from the interposition of a fluid, 34, between sphere 1 and socket-base 10 so that sphere 1 floats on fluid 34 and does not touch socket-base 10. Three benefits derive from this: (1) sphere 1 may rotate almost frictionlessly within socket-base 10, (2) sphere 1 need not be

built to close spherical tolerances since it does not touch socket-base 10, and (3) ground vibrations reaching socket-base 10 are to some extent damped out by fluid 34 before impinging on sphere 1. (Vibration is an important consideration in astronomical telescope design.)

As has been stated, the axes about which the bearing member or sphere and its contents rotates bear none of the weight thereof. This is an important advantage of the mounting in comparison with mountings now in use such as the giant Mt. Palomar telescope. Its declination axis carries a weight of 140 tons while its polar axis carries 530 tons. Great cost went into designing and constructing axles which could bear such tremendous weights without serious deflection or deformation and consequent impairment of the accuracy and precision of the telescope. Another problem to be reckoned with in carrying great weights on axles is that of friction. Numerous methods are used to overcome or reduce friction. The polar axis journal of the Mt. Palomar telescope, for example, is "floated" on its bearing. Lubricating oil under high pressure is forced through small holes in the bearing and actually floats the journal (a large horseshoe-shaped structure) on a film of oil.

The larger an equatorial telescope mounting becomes, the greater become the problems of axle deformation, deflection and friction. The invention provides the means for rotating gigantic mechanism about two mutually perpendicular axes without the attendant problems of axle deflection, deformation and friction caused by such great weights. Rather than supporting tremendous weight upon axles as in prior-art mechanisms, the weight bearing surface of the invention is not on axles but is spread over a very large area of the supporting means. The axle stresses and deformation of prior-art mechanisms also vary with the various positions of the telescope. This is not a problem with the mounting of the invention since the axles bear none, of the weight regardless of the rotational position of the bearing member with its contents. Hence said member may be very heavily weighted with devices and instruments without the necessity of designing and constructing large, weight carrying axles as would be required by prior-art mechanisms. The member and its contents are preferably balanced by means of counterweights so that its center of gravity and its geometric center coincide.

The invention may also be used as a mounting for instruments other than optical telescopes. It may also be used with great advantage to mount other reflective structures used to receive radiations from other parts of the electromagnetic spectrum. Such other structures include solar concentrators,

radar antennas, and radio telescopes. Figure 9 is a perspective view of a mounting within which a representative parabolic structure 35 is mounted. The parabolic structure is focused on a target 36 which is supported on legs 37. The parabolic structure may be thought of as representing a parabolic reflector in the case of the solar concentrator, or a parabolic antenna in the cases of the radar antenna mounting or radio telescope. In the case of the radar antenna mounted within the sphere, ring 2 may be oriented horizontally with respect to both base 39 and the earth by raising sleeve 38 to the horizontal. This would yield an altazimuth type mounting. The radio telescope and solar concentrator applications necessitate that the plane of ring 2 be placed at an angle with respect to base 39 in the same equatorial manner as that described above for the optical telescope application. This is to say that the polar axis of the mounting must be fixed parallel to the earth's axis of rotation. Such orientation allows the instrument to follow the apparent motion of the celestial bodies (stars, sun, etc.), caused by the earth's rotation, by rotating the sphere on its polar axis. A solar concentrator can follow the sun all day, for example, by rotating ring 2 at the same angular rate at which the earth turns upon its axis, but in the opposite direction, thus keeping the sun's rays focused on target 36 all day.

WHAT I CLAIM IS:—

1. An instrument mounting comprising a base, a bearing member having substantially universally rotatable load-bearing support on said base, co-operating orienting means on said member and base distinct from said load-bearing support for independently displacing said member about at least two axes, said orienting means being substantially free from forces induced by the weight of said bearing member and of an instrument carried thereby in use, and comprising an orientation member external of said bearing member and rotatively mounted on said base for rotation in a plane about a first axis, means connecting said bearing member to said orientation member to rotate said bearing member with said orientation member about said first axis, said connecting means also permitting rotation of said bearing means relative to said orientation member and said base about a second axis.

2. An instrument mounting according to Claim 1 wherein said orientation member includes a ring section slidably mounted in a guide recess on said base.

3. An instrument mounting according to Claim 1 or 2 wherein said bearing member has a peripheral surface of spherical contour supported by said base.

4. An instrument mounting according to

Claim 3 wherein said base has a spherical socket in which said peripheral surface is seated.

5 5. An instrument mounting according to Claim 3 wherein the bearing member is supported by flotation in a fluid contained in said base.

6. An instrument mounting according to Claim 5 wherein the fluid is a liquid.

10 7. An instrument mounting according to Claim 5 wherein the fluid is a pressurized gas.

8. An instrument mounting according to any one of the preceding claims comprising a sphere-shaped bearing member, the means for orienting said member comprising means for rotating said member about a plurality of diameter at least two of which are mutually perpendicular, said orienting means being substantially free from forces induced by the weight of said member and including a concentric and at least partially-encircling ring structure external of said member and rotatively mounted on said member supporting means for rotation in a plane about the axis of said ring structure, means connecting said ring structure, to said member to rotate said member with said ring structure about said ring axis, said connecting means also permitting rotation of said member at least in a plane perpendicular to the plane of said ring structure and about an axis perpendicular to said ring axis.

35 9. An instrument mounting according to Claim 8 including means defining a guide slot in the supporting means for the ring structure which provides a guide for said rotation about said ring axis.

40 10. An instrument mounting according to Claim 9 including means for imparting rotating motion to the ring structure through the slot in the base thereby rotating the member in the plane of the ring structure.

45 11. An instrument mounting according to Claim 8 or 9 wherein a fixed circumferential line on the surface of the sphere-shaped bearing member always remains aligned with a fixed point on the socket-base re-

gardless of the rotational position of the sphere as governed by its orienting means, which circumferential line is formed by the intersection with the surface of the sphere, of a plane which is always perpendicular to one of said diameter and passes through the center of the sphere and which fixed point is formed by the intersection of an extension of the other of said diameters with the spherical surface of the socket-base.

12. An instrument mounting according to Claim 11 wherein an aperture extends along said circumferential line of the bearing member so that it is aligned with an aperture centred on said socket base fixed point at all operative positions of the sphere shaped member, said aligned apertures permitting connection between an instrument carried on the mounting in use and a position external of the bearing member without impeding the rotation thereof.

13. An instrument mounting according to any one of Claims 8 to 10 wherein the sphere shaped bearing member forms a tube of a telescope.

14. An instrument mounting according to Claim 13 wherein the telescope is an optical astronomical reflecting telescope.

15. An instrument according to Claim 13, wherein the telescope is a radio telescope.

16. An instrument according to any one of Claims 8 to 10 wherein the sphere shaped bearing member forms a structure of a solar concentrator.

17. An instrument according to any one of Claims 8 to 10 wherein the sphere shaped bearing member forms a structure of a radar antenna.

18. An instrument mounting substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Fig. 1

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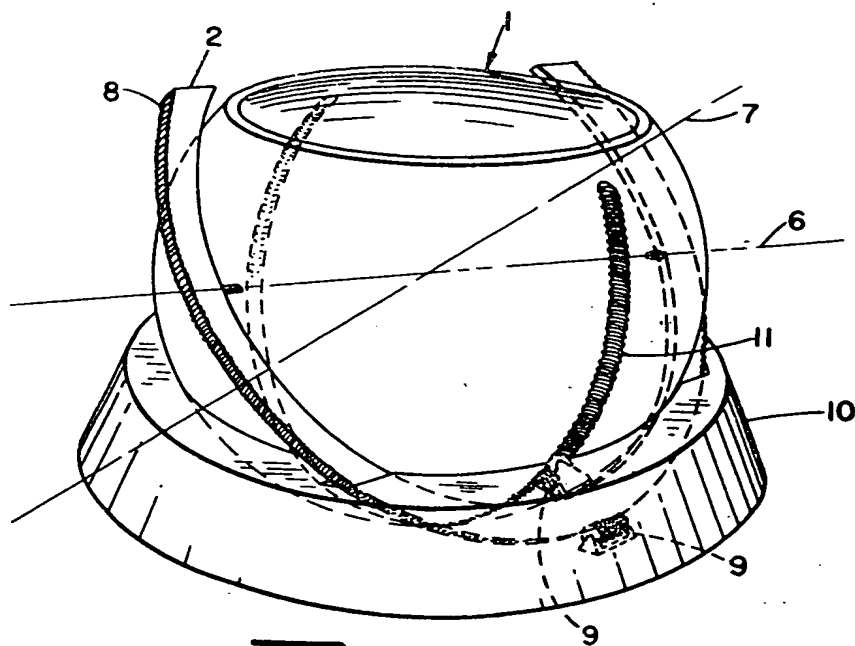


Fig. 2

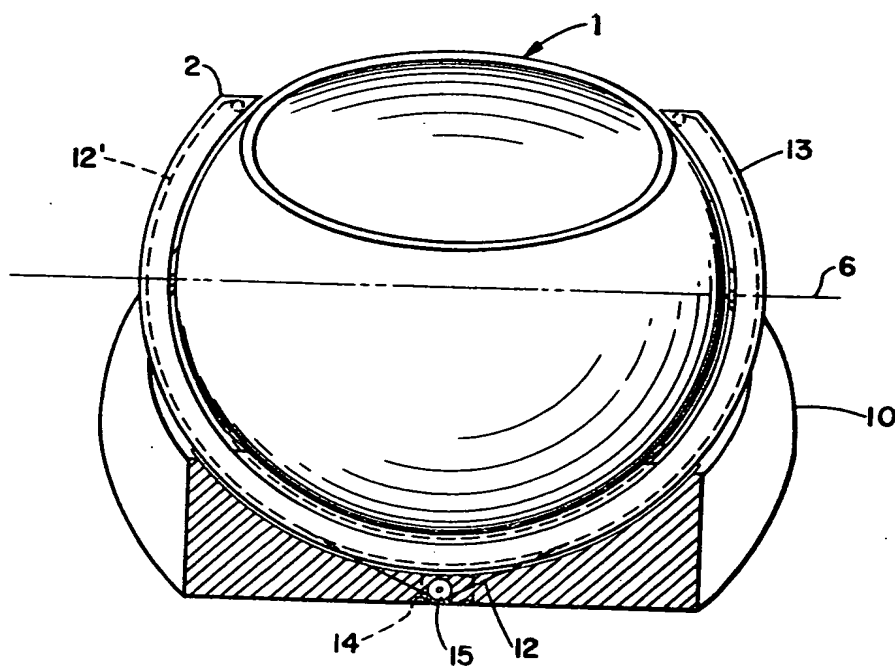


Fig. 3

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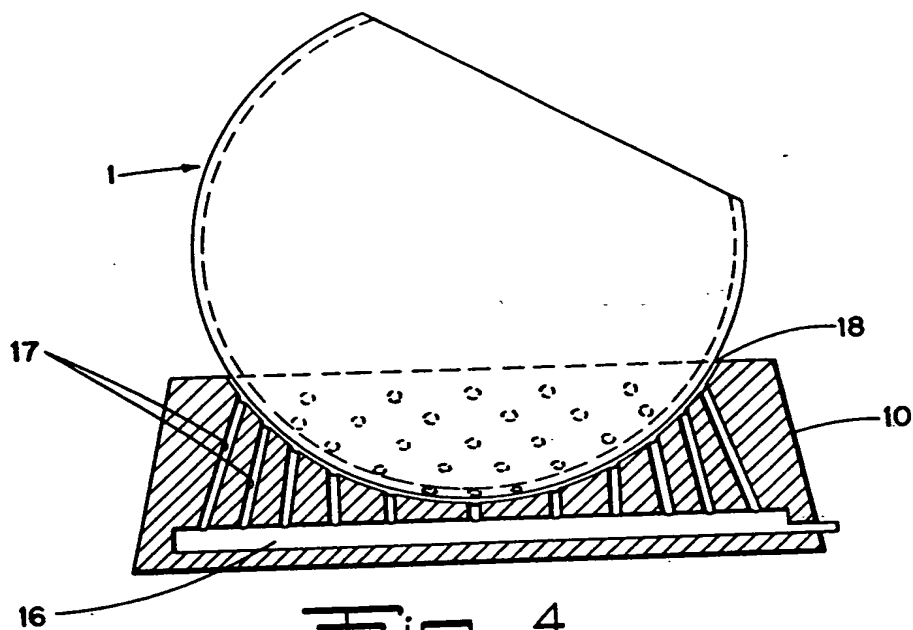


Fig. 4

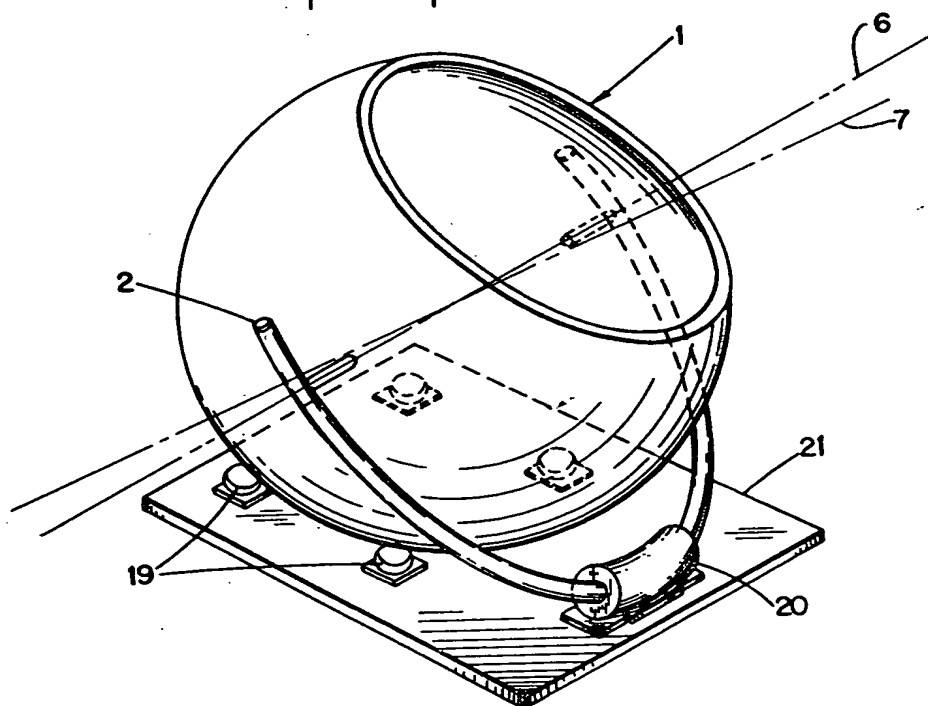


Fig. 5

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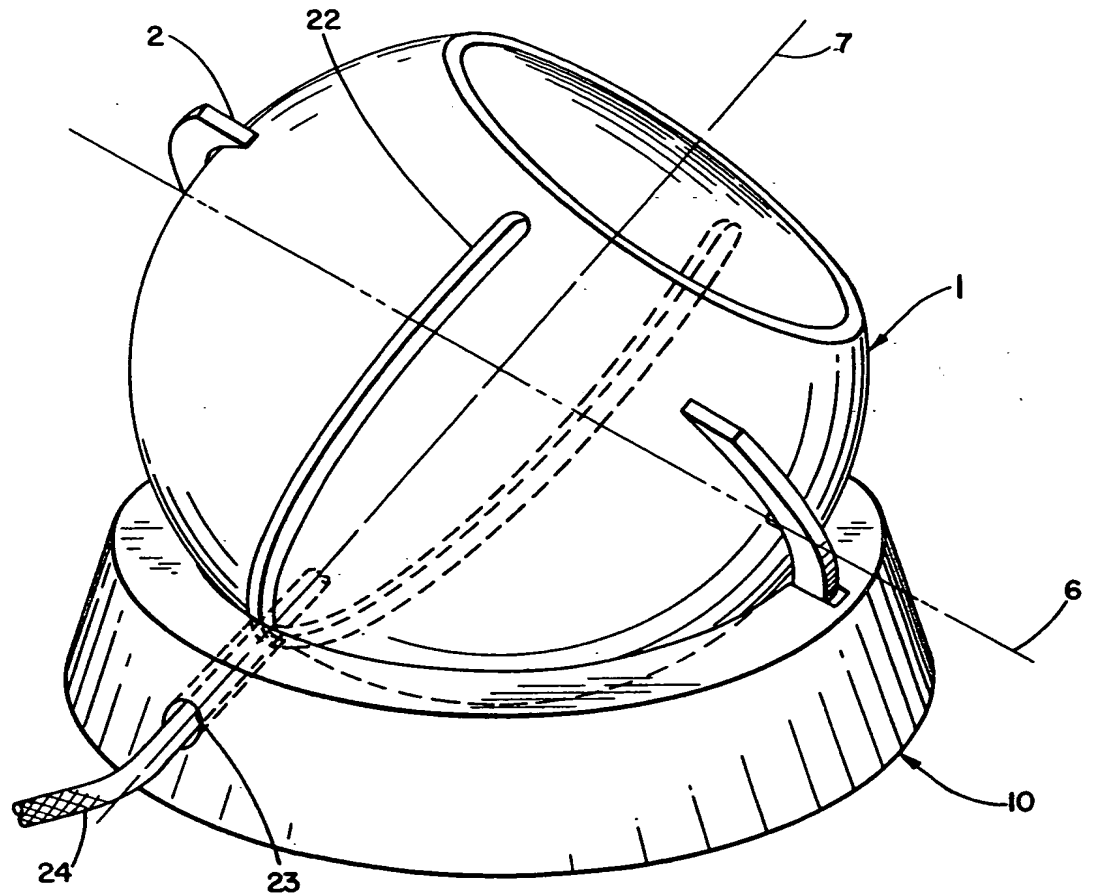


Fig. 6

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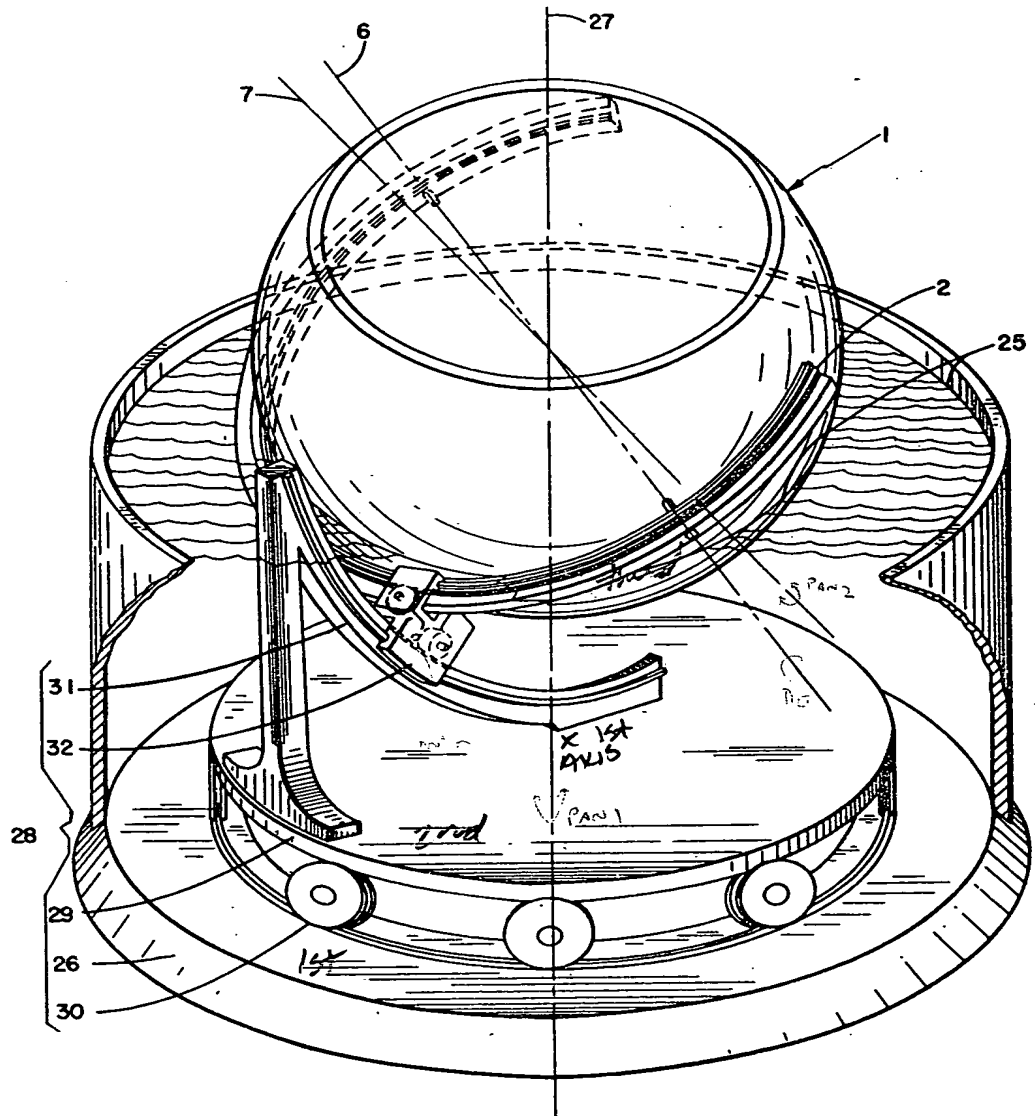


Fig. 7

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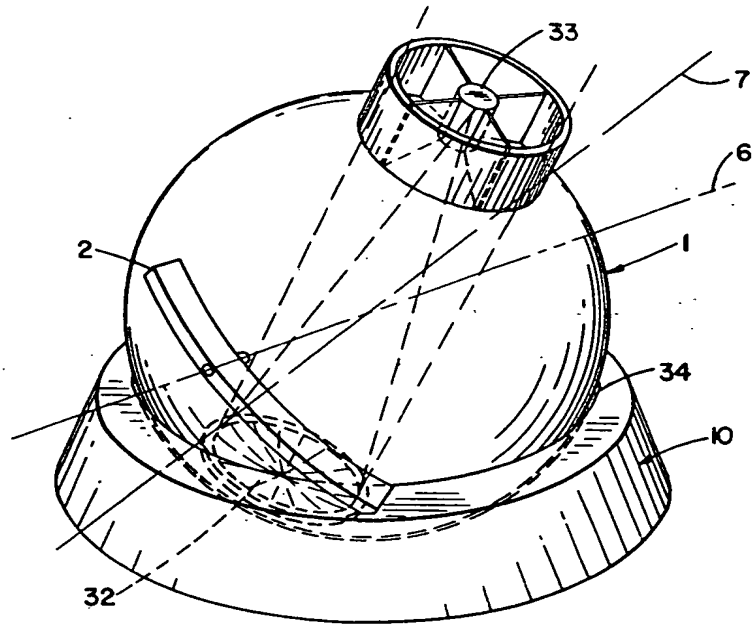


Fig. 8

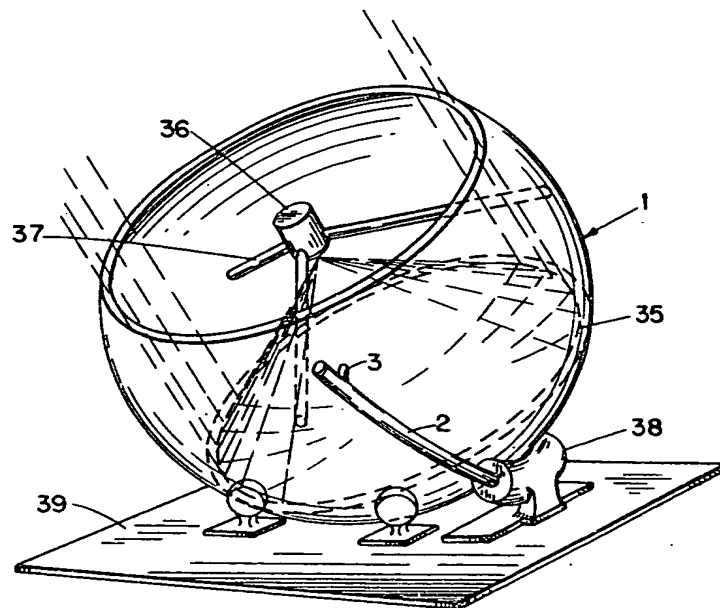


Fig. 9

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